TWO SPECIES OF *DELEPINEA* FROM NEW SOUTH WALES

by K. S. W. CAMPBELL and J. ROBERTS

ABSTRACT. The Viséan species *Chonetes aspinosa* Dun is re-described and is shown to be a typical representative of the genus *Delepinea* Muir-Wood. A row of cardinal spines is present and it is argued that such spines were normally present on all species of the genus. Details of the internal structure of both valves are given. A new species, *D. gloucesterensis*, is described from rocks of Middle-Upper Viséan age.

In 1902, Dun described ten large chonetoid specimens from various localities in New South Wales as a new species *Chonetes aspinosa*. Because he was unable to observe a second pair of adductor scars in the pedicle valve, and because the shell substance was not as thick as that of *Daviesiella llangollensis* or *Daviesiella* (now *Delepinea*) *comoides*, he explicitly excluded the species from *Daviesiella*. He did not observe the spine tubules in the cardinal area of the pedicle valve, and seems to have relied on general form and ornament for his generic identification. No suggestions were offered as to the significance of the species for overseas correlation. The next worker to record *C. aspinosa* was Benson (1921) who listed it in his *Census and Index of Burindi Fossils*, and added two more localities in northern New South Wales from which the species had been identified. There was no further record until Voisey (1940) noted an occurrence in strata mapped as Lower Burindi Series south of Barrington at the northern end of the Gloucester Syncline.

During the last five years or so large chonetoids have come to our notice from most areas of outcrop of Carboniferous rocks in the State. In some sections they are known to occur only once, and then through only a few feet of sediment. Elsewhere they are found on several horizons through over a hundred feet, and recently this figure has been increased to 3,000+ feet. In Queensland, too, similar species have been found at several widely separated localities in the Yarrol Basin, and are thought to range through much of the Viséan (Driscoll 1960; Maxwell 1961). One new species, *Daviesiella cannindahensis* Maxwell, has been described from the late Viséan limestones at Cannindah. Other specimens are referred to *Daviesiella* cf. *aspinosa* (Dun).

It is now clear that the New South Wales species, and almost certainly the Queensland ones also, are members of the genus *Delepinea* Muir-Wood. This matter is discussed below. There seems to be no record of an authentic *Daviesiella* anywhere in eastern Australia.
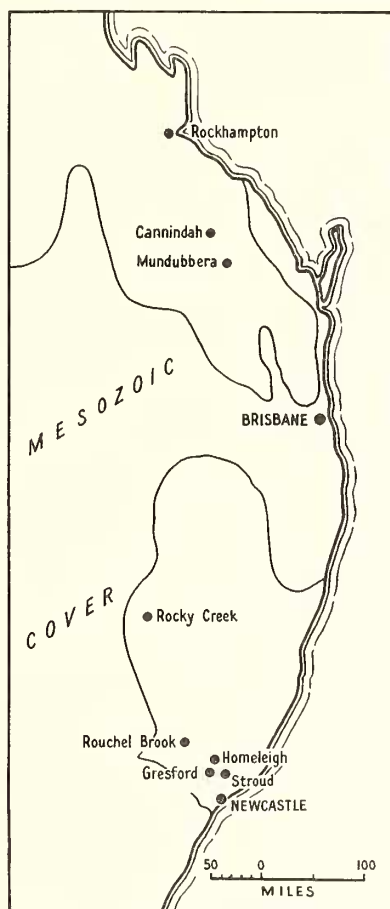
Since the species of *Delepinea* (and the related genus *Daviesiella*) have been proved to be of great value in stratigraphic zoning in Europe, we considered that a detailed systematic study of our material might provide useful data for our stratigraphic work. The localities from which the syntypes of *D. aspinosa* were obtained have been re-visited, with the exception of the one near Stroud which we have been unable to locate. Collections have been assembled from several localities in the area north-west of Dungog, Wiragulla near Wallarobba, Torryburn, Barrington, Rouchel Brook, and Rocky Creek

to the west of Barraba. The specimens from most localities are poorly preserved, and it is not possible to prepare enough interiors for the description of the variation of the critical internal characters. However, large collections of excellent material have been made at Rouchel Brook, Wiragulla, and Barrington, where preservation is in a matrix which is not soluble in weak acids, so that fine internal moulds can be prepared.

NOTES ON SOME MORPHOLOGICAL FEATURES

Cardinal spines and spine tubules. One of our specimens of *D. aspinosa* shows a row of cardinal spines on each side of the umbo. Though suggestions of spines have been noted by some authors (Simpson 1953, pp. 197–8), this is the only definite record of spines known to us, apart from that of Muir-Wood (1962, p. 104) for a single specimen of *D. comoides*, and it renders Dun's choice of a specific name singularly unfortunate. The spines observed in *D. aspinosa* are very delicate relative to the robust form of the shell as a whole, being not much larger than those of species of *Chonetes* s.s. There is little doubt that they have been removed from most specimens by abrasion, and the question now arises as to whether this is the explanation of their absence in other species. The presence of tubules through which the outer epithelium of the mantle could pass can be explained in three ways. (*a*) They were in process of atrophy since spines were no longer being developed. (*b*) They had become adapted to serve some secondary function. (*c*) They provided a passage for the outer epithelium which deposited cardinal spines functioning in much the same manner as those of *Chonetes* and related genera. These will now be discussed in order.

TEXT-FIG. 1. Locality map showing occurrences of *Delepinea* in eastern Australia.

(*a*) The function of spines in *Chonetes* is not clearly understood, but they most probably were stabilizing and/or supporting structures. It is clear that *Delepinea* must have evolved from some smaller early Carboniferous chonetid, probably *Megachonetes*, and it is possible that the spines would atrophy as the shells became larger and were stabilized by their own weight. This presumably is what has happened in the genus *Daviesiella*, in species of which neither external spines nor spine tubules are present. If loss of spines occurred in *Delepinea* and the tubules were not adapted to serve some other function, they too would be reduced during the history of the genus. There is an example of this phenomenon in the species *Anoplia nucleata* (Hall) (see Muir-Wood 1962, pp. 53–55) and related forms which are thought to have developed from normal chonetids by complete spine reduction, but which have no normal chonetid tubules. Instead, on each side of the umbo there are one or more pairs of highly inclined tubules,

which apparently did not penetrate the outer surface of the shell. No such feature is found in *Delepinea*, in which the only modification observed is the opening of the tubules through the cardinal area rather than along the cardinal ridge (Pl. 80, fig. 9). This has been noted on only one individual out of some fifty examined, and it could be pathological. Considering the matter from another point of view, if increasing size were causing the reduction and atrophy of the spines it might be expected that though the juveniles would be supported by spines, the massive adults would not be. In these circumstances, tubules would be present near the umbo, but not at the extremities of the hinge. In fact, they are invariably present along the whole hinge, and become progressively greater in diameter toward the extremities. Thus there appears to be no evidence that the tubules are vestigial.

(*b*) George (1930, p. 555) has suggested that the tubules functioned as sockets to receive denticles situated along the hinge of the brachial valve. It is not clear how a tubule containing an invagination of epithelium could function as a socket, or why it should be necessary for such sockets to remain open to the exterior throughout life. No figures of denticles along the hinge of the brachial valve have been published for any species, and none of our specimens shows these structures though careful search has been made for them. The explanation seems to be quite untenable. The tentative suggestion that 'extensions of the mantle passing through the hollow tubules of the ventral interarea formed anchoring strands of non-calcareous tissue' has been advanced by Simpson (1953, p. 199), but such a modification of the mantle seems most unlikely. It should be noted, however, that with problems of this type the possibility of the acquisition of completely new secondary functions cannot be excluded, though it might be possible to show that the postulation of such is unnecessary. This possibility is discussed in the next section.

(*c*) There is no doubt that the living position of the shells would change as the mass of the shell increased, and there would be an accompanying change in the method of support. It is possible, for example, that the spines could change from being a stabilizing fan to a series of braces helping to hold the shell in a certain position in or on the substratum. Since it is known that at least two species of *Delepinea* carried spines which could have functioned in some such way as this, since the spines are only rarely preserved in these species, and since the tubules of these species are of the same type and arrangement as in other species, it is probable that spines were present in all species. It is unnecessary to postulate an entirely new secondary function for the tubules.

The muscle scars. Our specimens confirm the interpretation of the adductor muscle scars in the pedicle valve given by Muir-Wood (1962). The pair of accessory scars is invariably hard up against the main adductors and is usually difficult to differentiate from them. In most specimens the junction can be distinguished only by the abrupt change in direction of the fine surface ridges. There is no suggestion that they were developed from the diductors. It is clear, however, that the diductor scars do develop small sub-differentiated segments in front of the accessory adductors. These are triangular in shape and their surfaces are marked by ridges set at a slight angle to those of the main scars.

As is usual for species of the genus, our species have two pairs of adductor scars in the brachial valve, a large sub-triangular postero-lateral pair and a smaller elliptical

antero-central pair. Muir-Wood (1962, p. 99) describes the genus as having two pairs of adductor scars in the brachial valve, but considers (p. 16) that *D. carinata* has accessory adductors in addition. These, however, are not shown on her text-fig. 20*a* (which in fact shows only one pair of scars), and cannot be distinguished clearly on her pl. 14, fig. 5*b*. None of our material shows any sign of such structures.

Cardinal process and chilidium. The same basic pattern is present in the cardinal processes of all species described to date, viz. a broadly bilobate anterior face and a quadrilobate posterior face. The published figures show that the shapes and relative sizes of the lobes on the posterior face, and the shape of the anterior face vary considerably from species to species. More attention should be directed to these features in systematic studies.

Due to its exposed position, the chilidium is very vulnerable to abrasion, and this sometimes creates the false impression that it is absent or deeply notched. In well preserved specimens it always seems to be entire. It is fused on either side to the ridges marking the lateral boundaries of the cardinal process.

Brachial ridges. These have not been observed previously in members of the genus. Among the specimens of *D. aspinosa* from Wiragulla are several which show weak ridges, and one (Pl. 81, fig. 9) in which they are superbly developed. The brachial platform is slightly raised and is smoother than the surrounding areas. In comparison with those of other chonetids, these platforms are relatively small. The ridges themselves are not continuous around the antero-lateral part of the scar. Their anterior ends are hooked in towards the median septum in the manner described by Muir-Wood (1962, p. 98 and fig. 19*b*) for *Daviesiella llangollensis* (Davidson). These structures in the latter species therefore would probably be best interpreted as the terminations of much larger ridges which have not been preserved.

STRATIGRAPHY

The stratigraphy of the Rouchel basin is very incompletely known. Osborne (1950) stated that the sequence consists of 7,000 feet of 'Lower Burindi Series' followed by 4,000 feet of 'Lower Kuttung Series', the latter being made up of about 700 feet (maximum) of coarse conglomerates and andesites which he referred to his 'Basal Stage' and 3,300 feet of his 'Volcanic Stage'. He believed that the several fossil occurrences in the Lower Kuttung, one of which is the *Delepinea aspinosa* occurrence in Stoney Creek, belonged to one horizon which he placed from 800–1,000 feet above the base of the Series. Recent work by B. A. Engel (personal communication) suggests that the thickness of the 'Basal Stage' is considerably in excess of 700 feet and is almost twice that figure near Rouchel; that, although the basin is much more intricately faulted than is shown on Osborne's map, it is possible to conclude that the fossil localities are not on the one horizon; and that the *Delepinea* beds are approximately 3,000 feet above the base of Osborne's Basal Stage. The *Delepinea* specimens occur in mudstones and very calcareous sandstones and are associated with a fauna containing large solitary corals, *Cladochonus*, *Rhipidomella*, *Leptagonia*, *Schizophoria*, *Schuchertella*, and a new genus of productoid brachiopod.

At Wiragulla, near Dungog, *D. aspinosa* has been collected from two horizons approximately 150 feet apart. The associated fauna has been described by Roberts

(unpublished Ph.D. thesis) and has been correlated approximately with the European Viséan Cu III β Zone. It contains *Echinoconchus gradatus* Campbell, *Waagenoconcha delicatula* Campbell, *Balanoconcha elliptica* Campbell, *Unispirifer striatoconvolutus* (Dun and Benson), '*Strophopleura*' *anterosa* Campbell, together with new species of *Inflatia*, *Gigantoproductus*, *Chonetes*, *Schuchertella*, *Athyris*, *Phricodothyris*, *Spirifer*, *Aviculopecten*, and *Streblopteria*. The lower horizon occurs in fine calcareous sandstone and oolitic limestone towards the top of the Ararat Formation (Roberts 1961), and the upper horizon in pale fawn mudstones near the base of the overlying Wiragulla Beds. The Wiragulla Beds pass conformably upwards into the Wallarobba Conglomerate Member of the Wallaringa Formation (the basal unit of the Kuttung Group and previously termed the Basal Stage by Osborne); the upper horizon is approximately 450 feet stratigraphically below the base of the Wallarobba Conglomerate. In terms of Osborne's nomenclature these horizons are in the topmost beds of the 'Lower Burindi Series'.

In the vicinity of Brownmore, to the north-west of Dungog, *Delepinea* occurs on several horizons through some 3,000+ feet of siltstones, sandstones, and occasional thin limestones mapped by Osborne (1950) as 'Lower Burindi Series'. Most of the specimens available are not specifically identifiable, and there are no well-preserved brachial valves. However, two individuals showing the characteristic internal structures of the pedicle valve of *D. aspinosa* have been found. The associated faunas have not yet been examined in detail, but they include the new productoid genus recorded above from Rouchel Brook, together with several of the species listed above from Wiragulla.

In the Barrington area, *D. gloucesterensis* is restricted to the Verulam Limestone which lies approximately 1,400 feet below the zone containing *Rhipidomella fortimuscula* (Cvancara 1958) which is now considered to be of Upper Viséan age, and approximately 1,600 feet below the *Marginirugus barringtonensis* Assemblage Zone. The sequence below the Verulam Limestone consists of Carboniferous marine mudstones and sandstones (the Wootton Beds) of unknown thickness, but probably somewhere near 6,000 feet. No fossil horizons are yet known in this part of the sequence.

Some indeterminable specimens of the genus have been recorded by Engel (1962) from the Myall area, on horizons near the top of the Wootton Beds. They lie consistently below the *Marginirugus barringtonensis* Assemblage Zone.

Finally, in northern New South Wales a few well-preserved specimens have been found in a coralline limestone interbedded in the Caroda Formation at Rocky Creek. The internals of these specimens are quite unknown, but from the external appearance we very tentatively refer them to *D. aspinosa*. The associated fauna consists of the corals


EXPLANATION OF PLATE 80

All figures natural size unless otherwise stated.
Figs. 1–9. *Delepinea aspinosa* (Dun).   1, Internal mould of a pedicle valve from Stoney Creek, Rouchel Brook; F5868 U.N.E.   2, Latex cast of part of a pedicle valve from same locality; F7916 U.N.E.   3, Internal mould of same, ×1·2.   4, Same ×1·5.   5, Latex cast of cardinal margin showing broken spines; from same locality; F7914 U.N.E. ×1·5.   6, 7, Ventral and posterior views of an internal mould of a pedicle valve from same locality; F5863 U.N.E.   8, 9, Two views of an internal mould of a pedicle valve showing the tubules penetrating the cardinal area and the sharply differentiated secondary adductor scars; from the vicinity of 746893 Dungog; 14060 A.N.U., ×1·5.
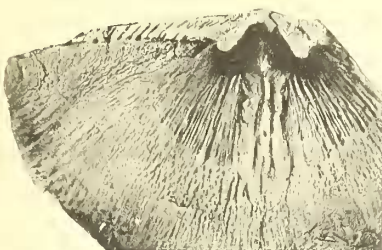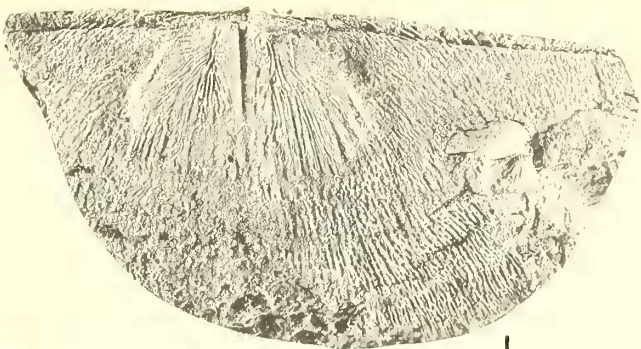
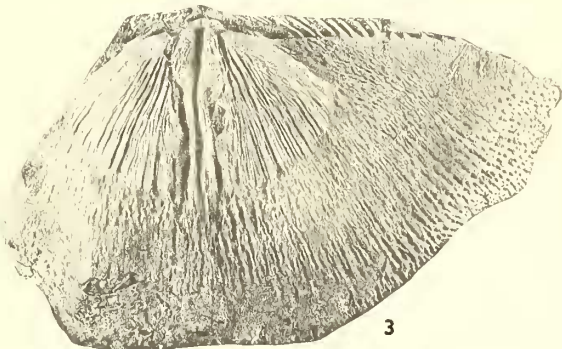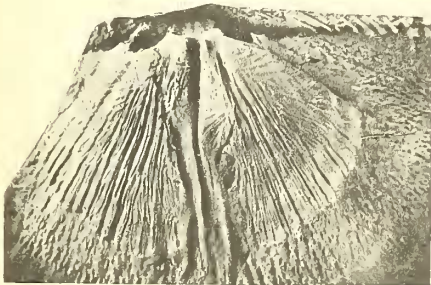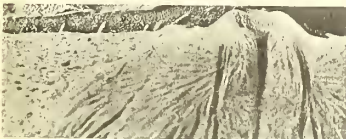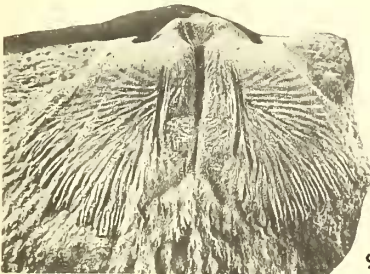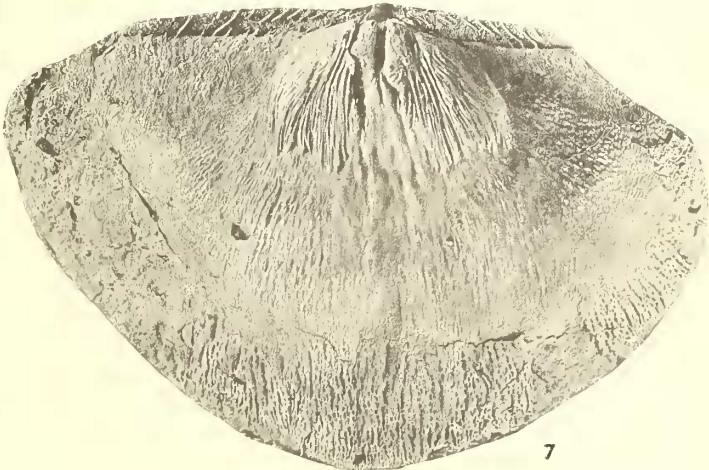*Amygdalophyllum etheridgei* Dun and Benson, *Lithostrotion* cf. *stanvellense* Etheridge, *L.* cf. *arundineum* Etheridge, and *Syringopora* cf. *syrinx* Etheridge, an assemblage considered by Hill (1934) to be of Viséan age (*Dibunophyllum* Zone).

The occurrence of *D. aspinosa* with similar faunas at Rouchel Brook, Brownmore, and Wiragulla suggests a probable correlation. The great thickness of sediment at Brownmore in comparison with that at Wiragulla is consistent with the facies interpretations of Roberts (1961). Other significant implications are that the base of the 'Volcanic Stage' has been placed by Osborne at quite different levels in the Rouchel Basin and the Wallarobba Syncline, and that coarse sedimentation of 'Kuttung' type began earlier at the former locality than the latter.

Nothing definite can be said of the time relationships of *D. aspinosa* and *D. barringtonensis*. They are not yet known in the same sequence and the associated faunas have not been studied in sufficient comparative detail to offer independent faunal evidence of age.

SYSTEMATIC DESCRIPTIONS

Delepinea aspinosa (Dun) emend.

Plate 80, figs. 1–9; Plate 81, figs. 4–10

1902 *Chonetes aspinosa* Dun, p. 71, pl. 19–20.

Types. The extant syntypes are now housed in the Australian Museum, Sydney, under catalogue numbers F35596–F35601. The originals of Dun's pl. 20, fig. 5 and pl. 19, fig. 3 are missing. The specimens from Rouchel Brook are moderately well preserved and in view of the abundance of material now available from that locality we are choosing F35597, figured by Dun, pl. xix, fig. 1, as lectotype. It is not as badly shattered as Dun's figure indicates, and is in fact in a fine state of preservation.

Description. Exterior: Pedicle valve strongly convex, almost globose, with the greatest convexity towards the umbo; lateral slopes evenly curved; cardinal extremities slightly flattened; sinus weak or absent; no geniculation; outline at early growth stages semielliptical, but semicircular in the adult; greatest width at, or slightly anterior to, the hinge; cardinal area approximately 3·5 mm. high directly beneath the umbo in a shell 55 mm. long and 5·0 mm. in one 70 mm. long; cardinal area flat to very concave, orthocline, and tapers gradually to a point at the extremity of the hinge; delthyrial angle 90°–95°; pseudodeltidium slightly arched, with a highly concave anterior edge, and occupies one-third the length of the delthyrium measured down the mid-line; cardinal ridge with row of spines spaced 1·2–2 mm. apart; lateral spines *c.* 0·5 mm. in diameter and probably 4–5 mm. long; costellae very variable in number being much finer and more numerous after a new series is inserted; five to nine costellae per 2 mm. on various parts of the shell; costellae regularly arranged except on the adult portion where they are sometimes highly distorted; increase both by bifurcation and intercalation.

Brachial valve moderately and evenly convex; deepest at the middle of the valve; cardinal area catacline, and 2·5 mm. high at the umbo in shells *c.* 75 mm. wide; chilidium full height of area, broadly convex; costellae as on pedicle valve, increase both by bifurcation and intercalation, and average *c.* nine per 2 mm.

Interior: Interior of pedicle valve marked by usual chonetine grooves and tuberculate ridges, covering almost the whole surface outside the muscle scars in juveniles, but confined to the anterior half of the surface in adults; remainder of surface in adults

with indistinct, short, non-tuberculate ridges; juveniles and young adults with regular continuous ridges, adults with discontinuous shorter ridges and longer, more widely spaced tubercules; median septum in juveniles very thin and low, but in adults blunt, thick, rising from a massive rounded callus in the apex of the umbonal cavity and extending *c*. one-quarter the length of the muscle field; anterior edge of septum not denticulate; in well preserved specimens septum uniform in height and truncated anteriorly; teeth small for such a large species, and consist of small rounded projections extending straight forward from the hinge; callosities buttress teeth and occasionally leave small pits on their outer sides; shoulders of valves in juveniles only slightly thickened, but thickening greatly increased in adults, the whole cardinal area being backed with callus.

Greatest shell thickness observed is 6 mm. in region adjacent to muscle scars; muscle field in juveniles flabellate, slightly impressed, rounded anteriorly, pointed posteriorly, and with straight postero-lateral limits at angles of 25°–35° to the hinge; in adults, muscle field much broader and not pointed posteriorly, more nearly straight anteriorly and increasingly convex postero-laterally; adductor scars scarcely distinguishable in juveniles; in adults clearly defined, oval, dendritic, with width from 0·5 to 0·8 times length, and extending from the posterior extremity to the mid-point of the whole muscle field or slightly beyond; anterior and posterior adductors often difficult to distinguish, but anterior pair well rounded and situated against the front edge of the posterior pair; adductor attachments often run well up the sides of the median septum; diductor scars usually with deep longitudinal striations causing a serration of their anterior edges; secondary diductor scars immediately in front of adductors (often in contact with them), and lie within 1–2 mm. of the mid-line in the valve; these scars usually widest posteriorly and tapering toward the front, but sometimes the opposite holds; striations run forwards and inwards, clearly distinguishing them from the main diductors; tubules through cardinal area normally oriented for the genus, circular or slightly elliptical in cross section; tubules near the umbo taper posteriorly, those toward the cardinal margins taper more gently, maintain a uniform diameter throughout or even occasionally expand slightly posteriorly; diameter of tubules 2 cm. from umbo (measured at mid-length of tubule) 0·2–0·45 mm., average 0·3 mm.

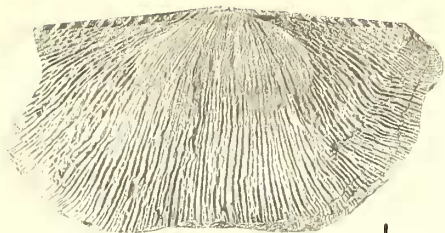All figures natural size unless otherwise stated.

Figs. 1–3. *Delepinea gloucesterensis* sp. nov.   1, Internal mould of the pedicle valve of a young specimen from 913371 Gloucester; F5884 U.N.E.   2, 3, Latex cast of the exterior of a brachial valve, and posterior view of the cardinal process, F5910 U.N.E. from same locality. The chilidium is broken.   ×1 and ×2 respectively.

Figs. 4–10. *Delepinea aspinosa* (Dun).   4, 5, Latex cast of the interior of a brachial valve and posterior view of the cardinal process, F7921 U.N.E., from Stoney Creek, Rouchel Brook. Chilidium almost entirely broken away.   ×1 and ×2 respectively.   6, Latex cast of the interior of a brachial valve, F7917 U.N.E. from the same locality.   7, Latex cast of the interior of a juvenile brachial valve, 14062 A.N.U., from the vicinity of 746893 Dungog.   8–10, Latex cast of the interior of a brachial valve, and posterior view of the cardinal process, 14064 A.N.U. from the vicinity of 746893 Dungog.   ×1, ×2, and ×2 respectively.
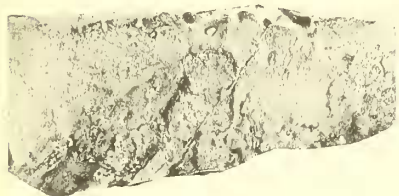
In figures 4, 6, 8, and 9, note the development of the platform and the shape of the lobes buttressing the front of the cardinal process. These are absent in the juvenile of figure 7.
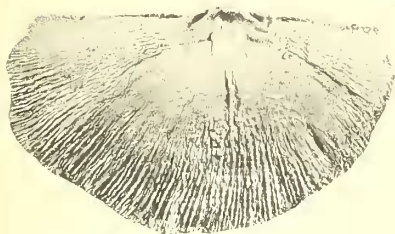
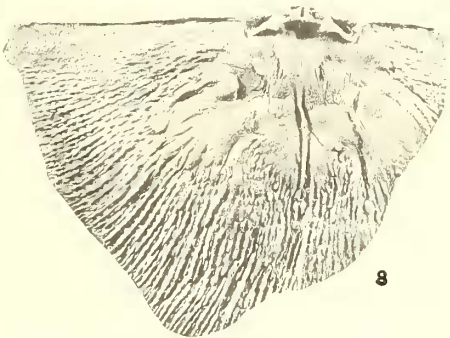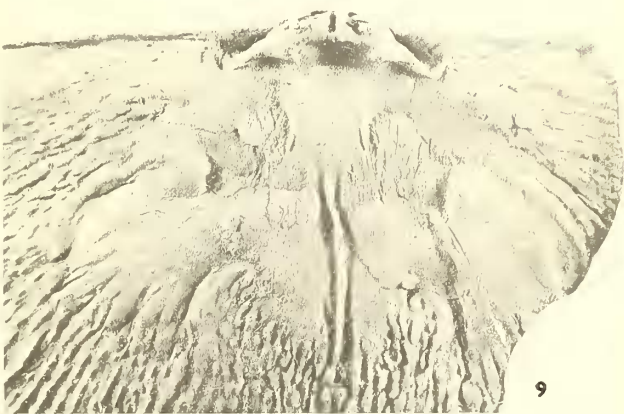CAMPBELL and ROBERTS, *Delepinea*